# 8

# TECHNICAL DESCRIPTION

# 8. TECHNICAL DESCRIPTION

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# 8. TECHNICAL DESCRIPTION

## 8.1 GENERAL DESCRIPTION OF THE LASER HEAD AND POWER SUPPLY

Each laser is made up of two major components: the laser head, from which laser output is obtained, and the power supply and control unit (PSU). These two components are connected via an electrically screened umbilical cable, which transfers all those services required for laser operation from the PSU to the laser head.

### 8.1.1 The Laser Head

The laser head comprises a metal case for screening, the laser discharge tube structure (including gas handling components), some components of the pulsed high voltage (HV) circuit, and fans for air cooling. By careful design, the emission of RF noise, which can cause interference and sometimes damage to electronic equipment, is restricted to very low levels. Special precautions have been taken in the design of the metal case containing the discharge tube to ensure that good metal-to-metal seals are made to all joints. The conductive metallic coatings on the sections where the lid and base of the box join should under no circumstances be painted. Since the metal box also protects the user from lethal voltages and high temperatures associated with the discharge tube, these lasers should NEVER BE OPERATED UNLESS THE LID OF THE CASE IS FIRMLY ATTACHED TO THE BASE. The user is strongly advised to read Chapter 2 on laser safety before attempting to operate the laser.

A glass-encapsulated capacitor is located at the high voltage end of the discharge tube assembly. This capacitor stores the energy to drive the discharge, and is pulse-charged from the PSU via a high voltage coaxial line.

### 8.1.2 The Power Supply and Control Unit (PSU)

The PSU contains the high voltage components, the remainder of the gas handling system, and the electronic circuits that control the automatic operation of the laser. The high voltage components include the high voltage transformer, the resonant charging circuit, and the thyratron switch. The thyratron is housed in an oil-filled tank. The gas handling system includes a vacuum pump, manual valves for servicing, and has provision for a small internal supply of neon buffer gas. Alternatively, connection can be made to an external gas supply. The control circuits use active power regulation to ensure constant tube temperature and output power stability, and also ensure a constant input power no matter what pulse repetition frequency (PRF) is selected within the specified range (see Section 8.2.1).

The only service required for the laser is a 3kW single phase electricity supply. All units are designed for 208/220/240 volt 50/60Hz operation.

## 8.2 SPECIFICATION

### 8.2.1 Technical Specification

Table 8.1 Technical specifications

| Model | CU10-A | CU15-A |
|---|---|---|
| Laser Medium | Copper | Copper |
| Wavelengths (nm) | 510.6/578.2 | 510.6/578.2 |
| Average Power (W) | 10 | 15 |
| Green/Yellow Ratio[1] | 2:1 | 2:1 |
| Pulse Energy (mJ) Max.[2] | 2 | 2.75 |
| Pulse Width (ns)[3] | 10-40 | 10-40 |
| Peak Power (kW) | 50 | 70 |
| Pulse Repetition Frequency (kHz) | | |
| Standard Adjustable Range | 8-14 | 9-13 |
| Extended Operation | 2-20 | 3-20 |
| Intermittent Operation | > 0.05 | > 0.05 |
| Timing Jitter (ns) | +/- 2 | +/- 2 |
| Beam Diameter (mm) | 25 | 25 |
| Divergence (mrad) | | |
| Full Angle Standard Cavity | 4 | 3 |
| Unstable Resonator (50% of power) | 0.4 | 0.4 |
| Run time on one copper load (hours) | >300 | >300 |

NOTES:

1 Using neon buffer gas, operating in the 8-12 kHz range

2 Maximum pulse energy obtained at minimum pulse repetition frequency

3 Depending on pulse repetition frequency

### 8.2.2 Services Required

Table 8.2 Services required

| Model | | CU10-A | CU15-A |
|---|---|---|---|
| Power Consumption (kW) | | | |
| Normal Running | | 2.0 | 2.5 |
| Maximum | | 2.5 | 3.0 |
| Electricity Supply (all models) | 208/220/240 volt 50/60Hz | | |
| Gas Supply (all models) | 99.995% Neon (CP Grade) | | |
| Gas Consumption (all models) | 0.5 litre-atm/hour while running and for first 8 hours after running | | |

## 8.3 GENERAL DESCRIPTION OF MAJOR SUBSYSTEMS

This section describes the major subsystems of the laser. These subsystems are the gas handling system, the cooling system, and the high voltage circuitry.

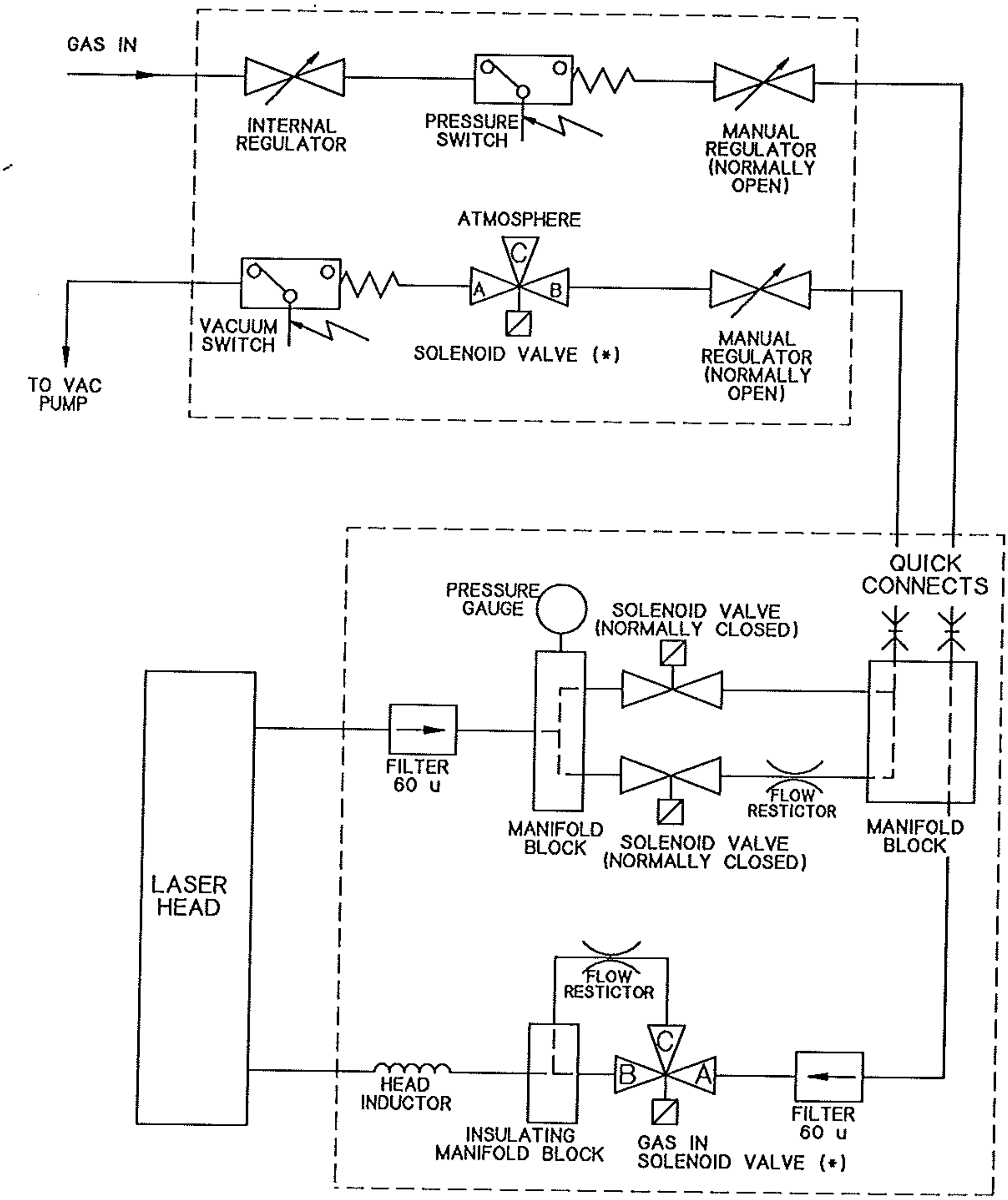
### 8.3.1 The Gas Handling System

Both the copper and gold vapour laser systems require a slow flow of neon buffer gas through the laser discharge tube for correct operation.

It is possible to use an internal gas cylinder within the PSU, or an external gas cylinder connected to the external gas port on the rear of the PSU. Switching between the internal and external gas supply is achieved by turning the gas supply select switch (T-Tap) on the rear of the PSU. Users are expected to provide their own gas supply: Oxford Lasers does not supply any gas cylinders with a laser.

Figure 8.1 is a schematic diagram of the gas handling system.

Once the gas supply has been selected and the laser switched on, all the gas flow control and gas pressure regulation is handled automatically by the control circuits in the PSU. The pressure switch adjacent to the gas input port detects the pressure from the gas cylinder and prevents laser operation if the pressure is below 1.5 bar. Assuming that sufficient gas pressure is available, the electronically controlled solenoid valves and the flow regulators govern the entire sequence of initial tube pump-down, gas-fill, and optimised gas pressure and flow rate for stable laser operation. The manual valves are used only for isolation during servicing.




(*) - 3 WAY VALVE OPERATION:

POWER OFF = A -> C OPEN, B CLOSED
POWER ON = A -> B OPEN, C CLOSED

Figure 8.1 The gas handling system

### 8.3.2 The Cooling System

In a device in which the core temperatures can exceed 1500°C with power inputs up to 2kW, it is obvious that some degree of insulation and cooling must be provided. All compact metal vapour lasers are air cooled, so it is very important that none of the air inlets on either the laser head or the PSU are obstructed.

Cooling is required for some time after the laser is switched off to avoid overheating. For this reason, two of the fans in the laser head are powered by a DC supply. During normal operation, a full-wave rectified supply powers the fans and recharges a sealed lead-acid battery, which takes over operation of the fans after the system has been shut down. Normally, this function is automatic. However, if for any reason these fans fail to operate after shut down, an EMERGENCY FAN START switch is located on the control and monitor panels inside the PSU. This switch connects the battery circuit directly. If it needs to be used, it should be switched off 30 minutes after shut down (sufficient time to cool the laser head), otherwise the battery will be drained of charge. Damage may occur to the laser head if the fans fail to operate during the cool down period.

The fans in the PSU are powered from the power supply and cool the thyratron tank, the resonant charging circuit and the vacuum pump. It is not necessary for these fans to operate after shut down. Failure of any of these fans is monitored by one or more interlock circuits.

### 8.3.3 The High Voltage Circuit

The general details of the high voltage circuit are shown in Figure 8.2. The high voltage power is provided by a single-phase transformer and rectifier located in the bottom of the PSU. Control of the high voltage is fully automatic, and the transformer output includes an "anti-trip" circuit to prevent thyratron latch up.

A capacitor bank is connected across the rectified output of the transformer to provide electrical smoothing of the HV supply. The DC high voltage is connected to the oil-filled thyratron tank.

A resonant charging circuit is used to achieve voltage doubling. The resonant charging circuit provides an efficient means of energy transfer to the storage capacitor bank of a voltage twice that of the supply. The storage capacitor bank is charged via the inductor located on top of the thyratron tank.

The charge in both the smoothing capacitor bank and the storage capacitor bank is safely short circuited to ground by a high voltage relay "dump" switch when the high voltage circuits are turned off. Refer to Chapter 2 (Safety) for further details.

The "peaking" capacitor on the laser head is charged from the energy storage bank via a heavy-duty HV coaxial line when the thyratron switch is fired. When the voltage on the peaking capacitor becomes sufficiently high, electrical breakdown occurs in the laser discharge tube.

In order to operate a metal vapour laser, it is necessary to provide high peak power electric discharge pulses of very short duration to excite the copper or gold atoms. In order to achieve large laser output powers, it is necessary to excite a large volume of atoms in this way. This requires an electrical switch which can reliably switch peak currents of the order of 1000 Amps in times as short as 20ns, at pulse repetition frequencies of 20kHz or more. Oxford Lasers uses hydrogen thyratrons to achieve these demanding operational requirements.

The thyratron switch has a heated cathode and three grids. The heated cathode provides a source of thermionic electrons. During the interpulse period, a cloud of electrons is built up between positively biased GRID 1 and the cathode. GRID 2, which is negatively biased, has a positive voltage pulse applied to it to cause the thyratron to switch. GRID 3 is earthed and aids switch-off of the thyratron at the end of each pulse.

The hydrogen thyratron incorporated in the HV circuit of the laser is an English Electric Valve Co. (EEV) model CX1535 thyratron. Special precautions have been taken to maximise its operational lifetime. The warranted thyratron life of the laser is 1000 running hours from date of delivery, whichever is sooner. However, a thyratron could well be expected to give in excess of 1000 hours

operation before requiring replacement.

For correct operation, the thyratron must be electrically heated and MUST ONLY BE OPERATED WHILE IMMERSED IN OIL. The time taken for the thyratron to reach its correct operational temperature is approximately 7 minutes. When the START switch is pressed, this thyratron warm-up period starts. The end of the period is indicated by the illumination of the HIGH VOLTAGE WARNING indicator. The automatic control of the high voltage circuit ensures that the thyratron is only ever operated when the heater has brought the thyratron to operating temperature, and thus helps to maximise the lifetime of the device.

The oil in which the thyratron is immersed must be prevented from overheating. The fans in the PSU provide important cooling of the thyratron oil and must not be covered. The laser should not be operated if any of the fans on the laser head or the PSU are not functioning. However, if the operator should fail to notice that a fan has malfunctioned, internal interlock circuits will shut down the laser and thus prevent damage to major PSU components.

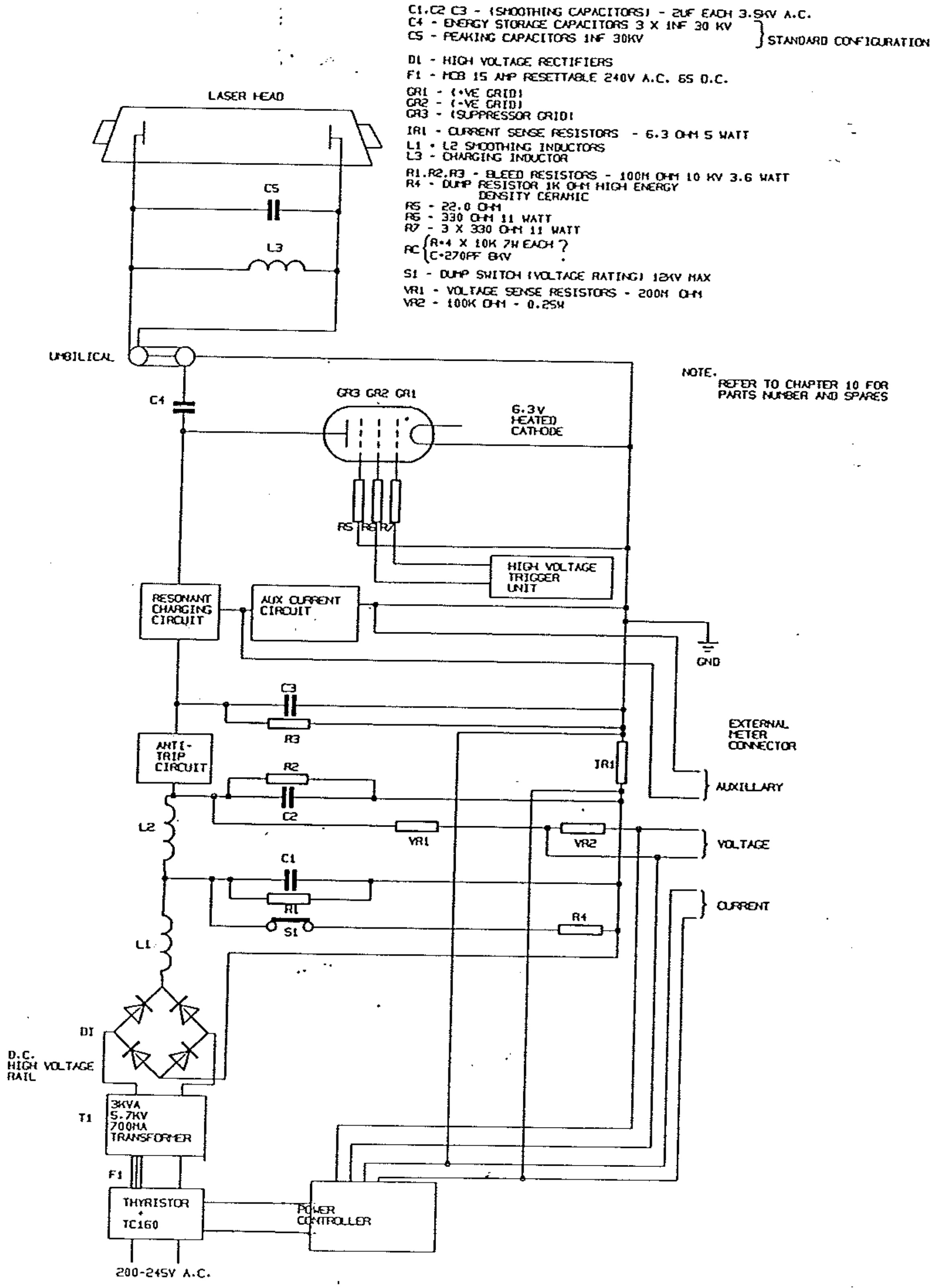



Figure 8.2 The high voltage circuit